MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

DET5088 – ANALOG ELECTRONICS 3

(Diploma in Electronic Engineering)

9 MARCH 2020
2:30 PM – 4:30PM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **6** pages excluding cover page and appendix.
2. Answer **ALL** questions. All necessary working steps must be shown.
3. Write all your answers in the answer booklet provided.

QUESTION 1 [25 marks]

(a) Name any **6 types** of applications of an operational amplifier.

(6 marks)

(b) Describe virtual ground condition, which exist in an op-amp circuit.

(3 marks)

(c) Sketch an ideal integrator op-amp and an ideal differentiator op-amp.

(6 marks)

(d) State the functions and sketch the graph of ideal gain $|A_v|$ versus frequency (in Hz) of the following filters:

(i) Low Pass Filter

(2 marks)

(ii) High Pass Filter

(2 marks)

(iii) Band Pass Filter

(2 marks)

(iv) Band Reject Filter

(2 marks)

(v) All Pass Filter

(2 marks)

Continued ...

QUESTION 2 [25 marks]

(a) Briefly explain the following terms, which influence a practical op-amp circuit.

(i) Input bias current

(2 marks)

(ii) Input offset current

(2 marks)

(iii) Input offset voltage

(2 marks)

(b) Explain the process to convert an unregulated AC supply into a DC regulated supply by using a transformers, rectifier, filter and voltage regulator in a power supply system. Sketch the signal waveforms passing through each of the related components.

(8 marks)

(c) Describe the operation of a crystal oscillator.

(2 marks)

(d) Explain the principle of Barkhausen Criterion used in the design of an oscillator.

(2 marks)

(e) Sketch a Wein-brigde oscillator.

(5 marks)

(f) Briefly explain the term "*ADC sampling rate*".

(2 marks)

Continued ...

QUESTION 3 [25 marks]

(a) An inverting operational amplifier and its corresponding input voltage (V_{in}) are shown in the Figure 1. Given that the input voltage, output voltage and capacitor voltage are zero at time, $t=0$. Calculate, draw and label the output waveform assuming this is an ideal operational amplifier.

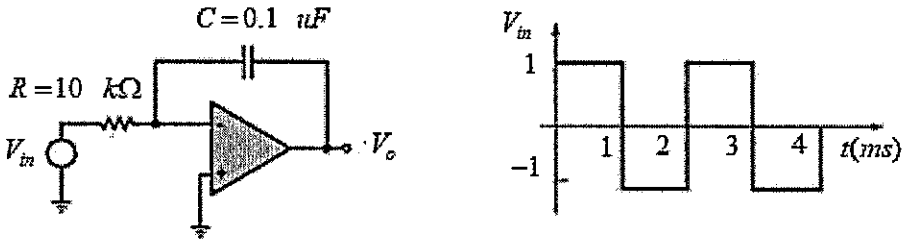

Figure 1 (7 marks)

(b) Figure 2 shows a practical op-amp with $V_{IO} = 2mV$, $I_{IO} = 5nA$ and $I_B = 60nA$

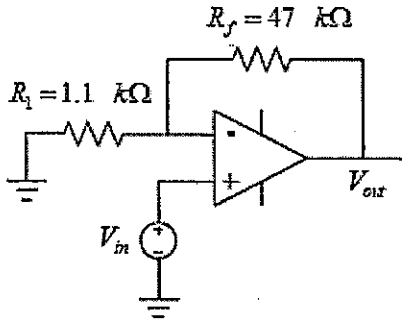

Figure 2

(i) Calculate the output offset voltage due to the input offset voltage.

(3 marks)

(ii) Calculate the total output offset voltage.

(3 marks)

(iii) Draw the circuit used to compensate the output offset voltage due to I_B and briefly explain the circuit.

(4 marks)

Continued ...

(c) A two pole filter has a voltage transfer function of $H(s) = \dfrac{5000000/s}{1000000/s + 500 + s}$.

Find the K, Q and w_o.

Hint:

$$H(s) = \frac{k_2 s^2 + k_1\left(\frac{w_o}{Q}\right)s + k_o w_o^{\,2}}{s^2 + \left(\frac{w_o}{Q}\right)s + w_o^{\,2}}$$

$$H_{LP}(s) = \frac{K w_o^{\,2}}{s^2 + \left(\frac{w_o}{Q}\right)s + w_o^{\,2}}$$

(8 marks)

Continued ...

QUESTION 4 [25 marks]

(a) Design a first order Low Pass Filter which can accommodate $f_o = 20kHz$, $K = 10$ with $R_1 = 2k\Omega$ and $C = 1nF$. Draw out the design.

(10 marks)

(b) When the AC input voltage of a certain power supply changes, the input to the voltage regulator decreases by 5V as a result and the output of the regulator decreases by 0.25V. The nominal output is 15V. Determine the line regulation in %/V.

(3 marks)

(c) Design a phase shift oscillator, which can accommodate an oscillation of 500 Hz. Given that the design has $C = 0.1$ uF and $R_S = 15k\Omega$. Sketch out the design.

(7 marks)

Continued ...

(d) A Schmitt Trigger Comparator is shown in Figure 3.

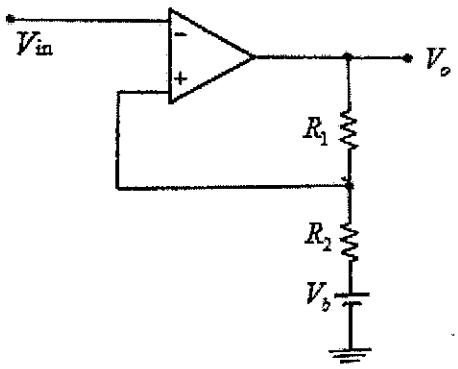

Figure 3

(i) Determine whether it is a Non-Inverting Schmitt Trigger Comparator or an Inverting Schmitt Trigger Comparator.

(1 mark)

(ii) Provide justification for your answer in Q4(d)(i).

(1 mark)

(iii) Calculate the hysteresis voltage given by $V_H = V_{UTP} - V_{LTP}$. Assume $V_{o,sat} = 10.5\ V$, $V_b = 5\ V$, $R_1 = 50\ k\Omega$ and $R_2 = 5\ k\Omega$.

(3 marks)

End of Page.

APPENDIX

Biquadratic voltage transfer function

Filter type	k_o, k_1, k_2	Voltage transfer function
Low-pass	1, 0, 0	$H_{LP}(s)=\frac{K\omega_o^2}{s^2+(\omega_o/Q)s+\omega_o^2}$
High-pass	0, 0, 1	$H_{HP}(s)=\frac{Ks^2}{s^2+(\omega_o/Q)s+\omega_o^2}$
Band-pass	0, 1, 0	$H_{BP}(s)=\frac{K(\omega_o/Q)s}{s^2+(\omega_o/Q)s+\omega_o^2}$
Band-reject	1, 0, 1	$H_{BR}(s)=\frac{K(s^2+\omega_o^2)}{s^2+(\omega_o/Q)s+\omega_o^2}$
All-pass	1, -1, 1	$H_{AP}(s)=K\frac{s^2-(\omega_o/Q)s+\omega_o^2}{s^2+(\omega_o/Q)s+\omega_o^2}$